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(71) Applicant(s)
Lotus Cars Limited
(Incorporated in the United Kingdom)
Hethel, NORWICH, Norfolk, NR14 8EZ,
United Kingdom

(72) Inventor(s)
James William Griffith Turner

(74) Agent and/or Address for Service
Boult Wade Tennant
Verulam Gardens, 70 Gray's Inn Road,
LONDON, WC1X 8BT, United Kingdom

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(56) Documents Cited
GB 2200952 A
EP 1072762 A
WO 1995/009298 A
US 5365895 A
US 4495902 A

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(54) Abstract Title
Valve operating mechanisms

(57) The present invention relates (with reference to Figure 1), to a valve operating mechanism for operating a poppet valve (10). The mechanism comprises: a cam (13) mounted on a camshaft (14); a first rocker (15) which is pivotally mounted on a first rocker shaft (17) and which is driven by the cam (13) to pivot in an oscillatory manner; and a second rocker (16) which is pivotally mounted on a second rocker shaft (21) spaced apart from the first rocker shaft (17) and which engages the poppet valve (10). The first rocker (15) has a cam surface (30) and the second rocker (16) has a reaction surface (31). A follower member (27) is arranged between the cam surface (30) and the reaction surface (31) in simultaneous abutment with both. As the first rocker (15) pivots the follower member (27) moves relative to the cam surface (30) and relays camming action of the part of the cam surface (30) engaged by the follower member (27) to the reaction surface (31) and thereby causes the second rocker (16) to pivot and impart motion to the poppet valve (10). A control mechanism (28,29) can move the follower member (27) relative to the cam surface (30) in order to vary which part of the cam surface (30) is engaged by the follower member (27). The rocker shafts (17,21) are arranged with respect to one another and the control mechanism (28,29) is configured such that when the follower member (27) is moved by the control mechanism (28,29) to increase maximum lift of the poppet valve then distance between the follower member (27) and the first rocker shaft (17) is increased and distance between the follower member (27) and the second rocker shaft (21) is decreased.

FIG. 1.

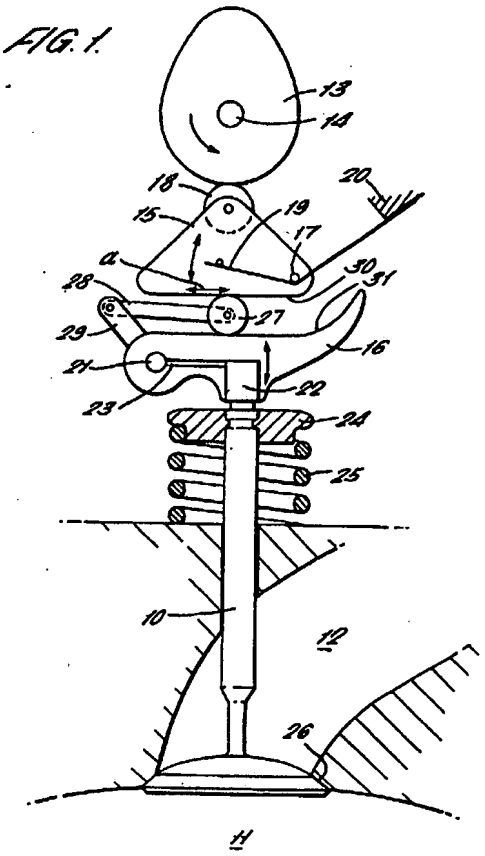

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FIG. 1.

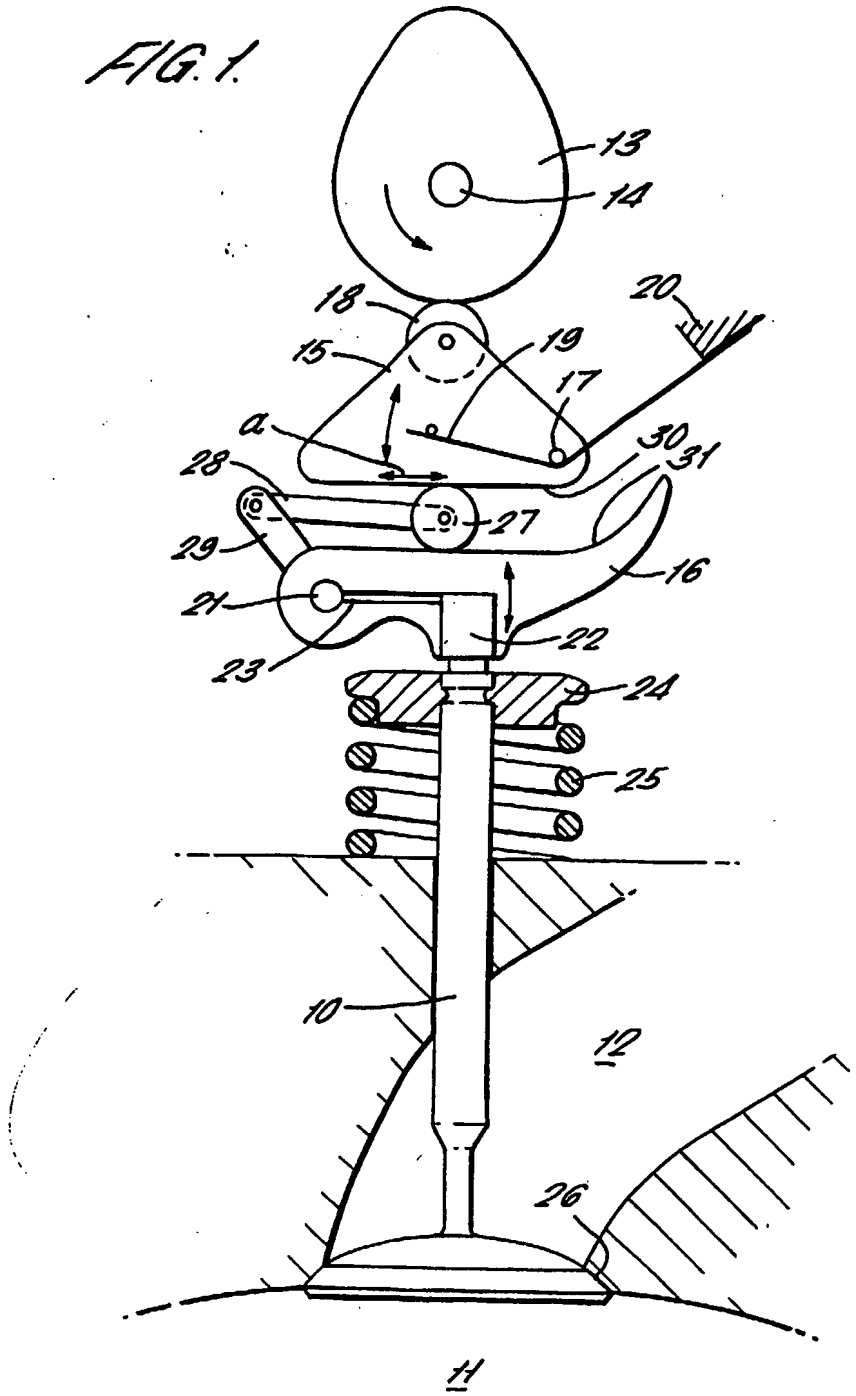


FIG. 2.

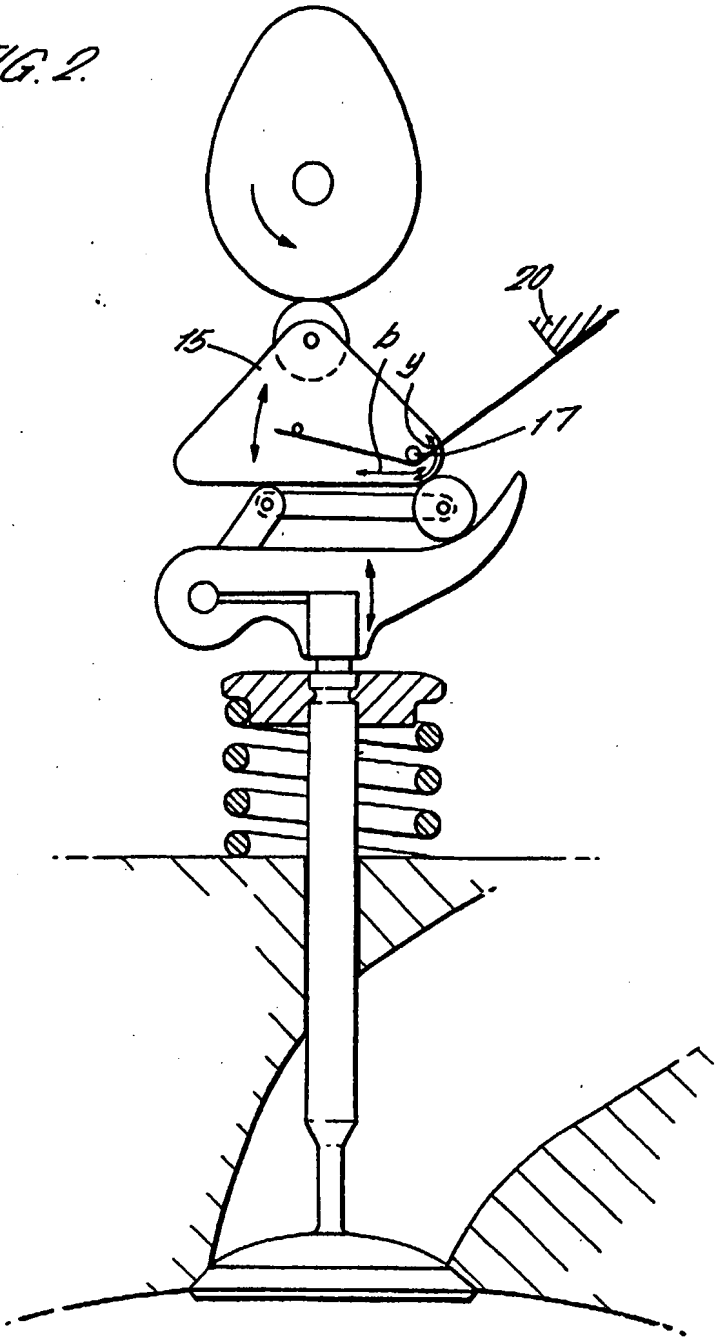


FIG. 3.

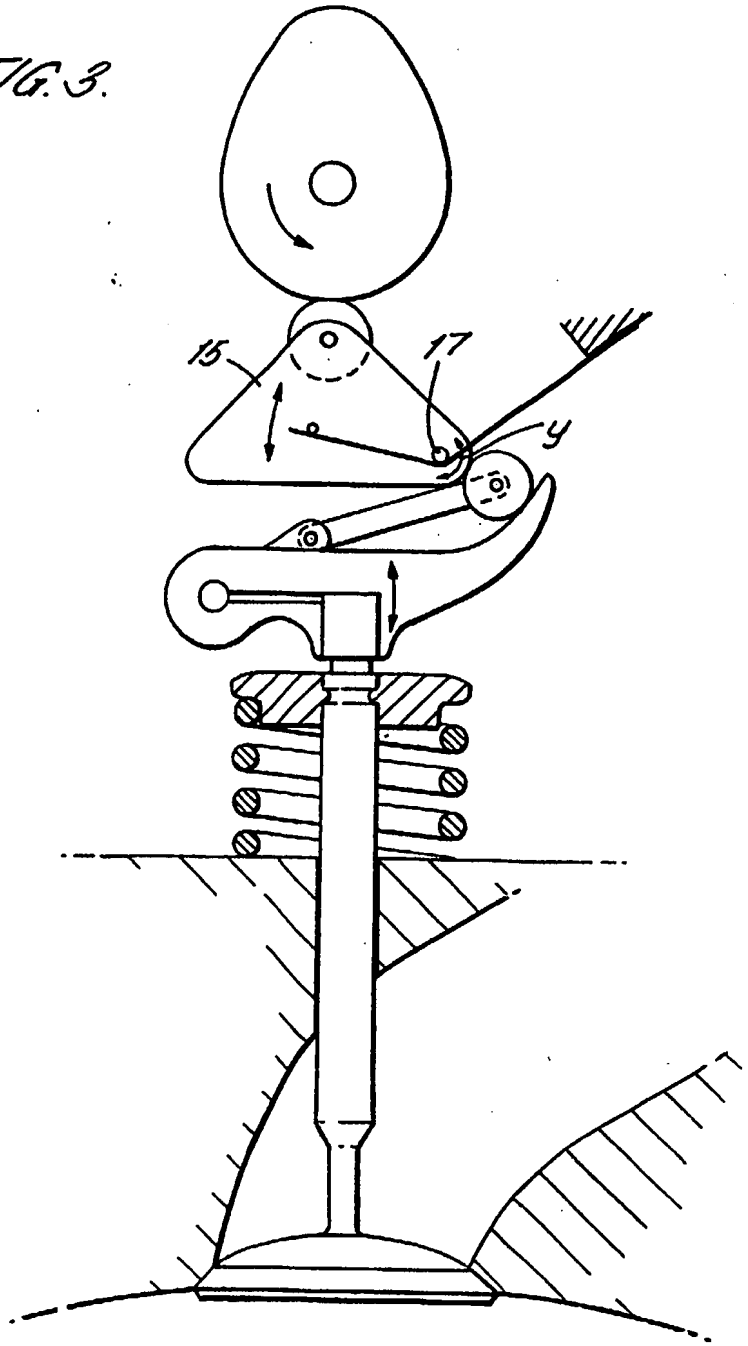
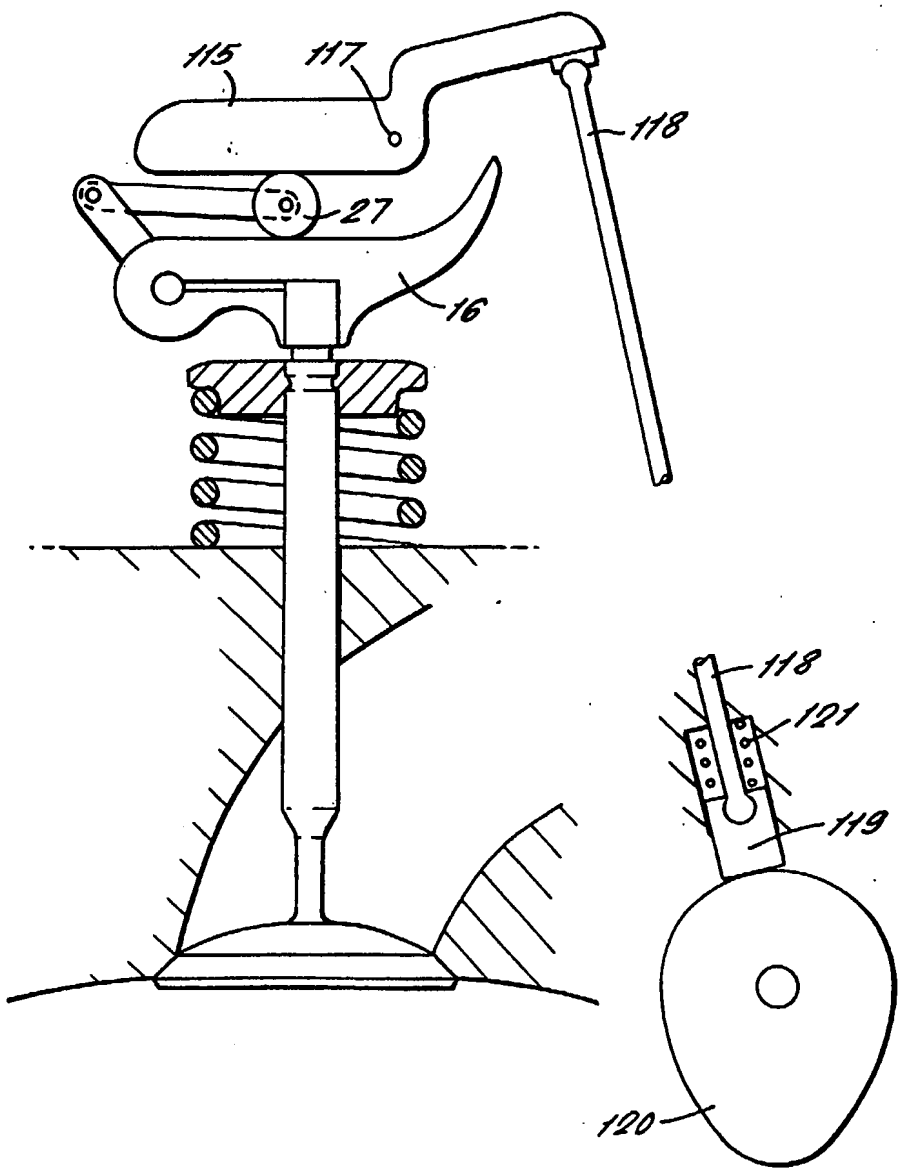


FIG. 4.



Valve Operating Mechanisms

The present invention relates to valve operating mechanisms suitable for operating poppet valves of an internal combustion engine.

Poppet valves are typically used as inlet and exhaust valves of an internal combustion engine, controlling gas flow into and out of working cylinders. The poppet valves of an engine are typically driven by cams on one or more camshafts of the engine. Historically the motion of each valve was controlled by the profile of a single cam and remained unchanged with changes in engine speed or load. However, it has been appreciated by many that it is advantageous to vary the opening period of a poppet valve and its lift with changing engine speeds and loads and many mechanisms have been proposed to achieve this.

In WO95/09298 there is shown a valve operating mechanism for operating a poppet valve in which a cam is connected to a crankshaft of the engine to rotate with rotation of the crankshaft. The cam drives a first rocker to oscillate about a rocker shaft. A cam surface of a chosen profile is provided on the rocker. A second rocker on a second rocker shaft engages the poppet valve. A cam follower is mounted on the second rocker and also engages the cam surface on the first rocker. The motion imparted by the cam surface to the cam follower is relayed to the second rocker which oscillates about its rocker shaft and thereby drives the poppet valve to open. A return spring acting on the poppet valve acts to return the open valve to its seat. The motion of the poppet valve can be varied by

selecting which part of the cam surface is engaged by the cam follower in each oscillation of the first rocker. A first part of the cam surface can be designed to such that no lift is imparted to the poppet valve as the cam follower follows the cam surface. Another part of the cam surface can be designed to impart a lift to the valve. The cam follower is moved relative to the second rocker in order to effect the selection of an appropriate part of the cam surface.

The mechanism of WO95/09298 has a disadvantage. in each rotation of the cam the roller follower only moves over the cam surface of the first rocker. Relative motion between the roller follower and the second rocker is only occasioned in order to vary valve lift and duration. As the cam follower is moved to achieve reduced valve lift and reduced valve opening duration the rocker ratio of the second rocker increases (this ratio being dependent on the distance from the point of contact of the cam follower/cam surface to the pivot axis of the pivot shaft of the second rocker). Thus the designer of the profile of the cam surface would be trying to achieve a profile of the cam surface which gave reduced valve lift despite the increasing rocker ratio. This is undesirable.

The present invention provides in a first aspect a valve operating mechanism for operating a poppet valve comprising: a cam mounted on a cam shaft for rotation therewith; a first rocker which is pivotally mounted on a first rocker shaft and which is driven by the cam to pivot in an oscillatory manner about the first rocker shaft; a second rocker which is pivotally

mounted on a second rocker shaft spaced apart from the first rocker shaft and which engages the poppet valve so that pivoting of the second rocker causes motion of the poppet valve; wherein the first rocker has a cam surface and the second rocker has a reaction surface and the cam surface and the reaction surface face each other; a follower member is arranged between the cam surface and the reaction surface in simultaneous abutment with both surfaces; as the first rocker pivots under camming action of the rotating cam the follower member moves relative to the cam surface and the follower member relays camming action of the part of the cam surface engaged by the follower member to the reaction surface and thereby to the second rocker to cause the second rocker to pivot about the second rocker shaft and hence impart motion to the poppet valve; and the follower member is connected to a control mechanism which can move the follower member relative to the cam surface in order to vary which part of the cam surface is engaged by the follower member during pivoting of the first rocker and thereby to vary the pivoting of the second rocker and hence the motion of the poppet valve; characterised in that the first and second rocker are arranged with respect to one another and the control mechanism configured by the control mechanism such that when the follower member is moved to increase maximum lift of the poppet valve then distance between the follower member and the first rocker shaft is increased and distance between the follower member and the second rocker shaft is decreased. This results in a simultaneous increase in rocker ratios for both rockers which is advantageous.

Preferred embodiments of valve operating

mechanisms according to the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic drawing of a first embodiment of valve operating mechanism according to the present invention, in a first operating mode;
Figure 2 is a schematic drawing of the first embodiment of valve operating mechanism, in a second operating mode;
Figure 3 is a schematic drawing of the first embodiment of valve operating mechanism, in a third operating mode; and
Figure 4 is a schematic drawing of a second embodiment of valve operating mechanism according to the present invention.

Turning first to Figure 1 there can be seen a valve operating mechanism for operating a poppet valve 10. The illustrated poppet valve is an inlet valve of an internal combustion engine of an automobile, controlling flow of a fresh change of air or fuel and air into a working cylinder 11 from an inlet passage 12.

A valve operating mechanism comprises a cam 13 which rotates with rotation of a camshaft 14 (driven to rotate by a linkage connecting the cam shaft 14 to a crankshaft (not shown) of the engine). The mechanism also comprises a first rocker 15 which is mounted on a rocker shaft 17 to be freely pivotal about the rocker shaft 17. The rocker 15 has a freely rotating roller follower 18 mounted thereon, the roller follower 15 engaging the surface of the cam 13. The roller follower 18 is biassed into engagement with the cam 13

by a spring 19 which acts between the rocker 15 and a fixed point 20. The rocker 15 has a cam surface 30 machined on the bottom of the rocker 15.

A second rocker 16 is freely pivotal about a rocker shaft 21, spaced apart from and parallel to the rocker shaft 17. A hydraulic lash adjuster 22 is located in the rocker 16, supplied by an oil passage 23 leading from the rocker shaft 21. The rocker shaft 21 is hollow and carries an oil supply which is relayed to the oil passage 23 via an aperture in the shaft 21 (not shown). The lash adjuster 22 abuts the top of a stem of the poppet valve 10. A collar 24 is fixed to the top of the stem of the poppet valve 10 and a valve spring 25 acts between a fixed point and the collar 24 in order to bias the poppet valve into engagement with its seat 26 (i.e. into a closed position). The rocker 16 has a reaction surface 31 machined on the top of the rocker 16.

Linking the rocker 15 and the rocker 16 is a roller follower 27. The roller follower simultaneously engages both the cam surface 30 on rocker 15 and also the reaction surface 31 machined of rocker 16. The roller follower 27 is rotatably mounted on the end of a control arm 28 which is in turn pivotally connected to an end of a control arm 29 which is mounted on the shaft 21 to rotate with the shaft. The shaft 21 will in turn be rotated by an electric motor (not shown) under the control of an electronic control system in a manner described later.

In figure 1 the roller follower 18 engages a base circle portion of the cam 13 and no lift is imparted to the poppet valve 10 by the operating mechanism. As

the cam 13 rotates from its illustrated position the camming action of the cam 13 will initially cause the rocker 15 to pivot anti-clockwise about the shaft 17. The anti-clockwise motion is conveyed via the roller follower 27 to the rocker 16 to cause the rocker 16 to pivot clockwise about the shaft 21 and thereby to move the poppet valve 10 away from its valve seat 26 (i.e. to open the valve). The roller follower 27 rolls along the cam surface 30 of the rocker 15 as the rocker 15 pivots. The lift imparted to the valve 10 is thus a function not only of the profile of the cam 13 but also of the profile of the cam surface 30. The part of the cam surface 30 along which the roller follower 27 rolls is indicated by 'a' in figure 1. Once the cam 13 has rotated past its point of peak lift then the foregoing is reversed and the rocker 15 pivots clockwise (under the direct influence of the spring 19 and the indirect influence of the valve spring 25) and the rocker 16 rotates anti-clockwise under the influence of the valve spring 25 until the poppet valve 10 is returned to its seat 26 (i.e. closed).

Figure 1 shows the valve operating mechanism in a first high lift operating mode in which the control arm 29 has been rotated to a position which constrains the roller follower 27 to follow the first portion 'a' of the cam surface 30. The figure 1 operating mode will be chosen for high speed/ high load operation of the engine.

Figure 2 shows the valve operating mechanism in a second operating mode in which the control arm 29 and is rotated to a position which forces the roller follower 27 to follow a second portion 'b' of the cam surface 30. This portion 'b' includes an initial

section in which no lift is imparted to the valve 10. This is achieved by constraining the roller follower to move along a part 'y' of the cam surface 30 of the rocker 15 which is of constant radius with regard to the rocker shaft 17. Whilst the roller follower 27 moves along the part 'y' the pivoting of the rocker 15 is not converted into pivoting of the rocker 16 and the valve 10 is kept closed. Once the roller follower leaves the part 'y' then further pivoting of the rocker 15 does cause rotation of the rocker 16 and hence lift of the valve 10. The maximum distance between the roller follower 27 and the rocker shaft 17 is less than in the figure 1 operating mode. The minimum distance between the roller follower 27 and the rocker shaft 21 is greater than in the figure 1 operating mode. Thus the poppet valve 10 has a lower maximum lift in the figure 2 operating mode than in the figure 1 operating mode. Also the duration of valve opening is reduced since the valve 10 remains closed during the initial and final parts of the oscillation of the rocker 15. The operating mode of figure 2 will suit part load operation of the engine.

In figure 3 a valve deactivation mode is shown. In the figure the roller follower 27 is constrained to move only along the constant radius part 'y' of the control surface 30 of rocker 15 and thus none of the rotation of the rocker 15 results in rotation of the rocker 16. In this mode the spring 19 alone serves to keep the roller follower 18 in contact with the cam 13.

The rocker ratios of both rockers 15,16 increase together and decrease together simultaneously as the control arm 28 moves the roller follower 27 along the

cam surface 30. This is because the rocker ratio of the rocker 15 is increased the greater the distance from the roller follower 27 to the rocker shaft 17 and the rocker ratio of the rocker 16 is increased the smaller the distance from the roller follower 27 to the rocker shaft 21.

Figure 4 shows a variant of the valve operating mechanism suitable for a push rod engine. The only difference between the figure 4 mechanism and the mechanism of figures 1 to 3 is that the rocker 15 is replaced by a rocker 115 which does not have a roller follower abutting a cam, but instead is driven by a push rod 118 which in turn is attached to and driven by a tappet 119 which engages a cam 120. A spring 121 acts between a fixed point and the tappet 119 to keep the tappet 119 in engagement with the cam 120.

The valve operating mechanism described above enables sufficient control over both valve lift and duration that when applied to operate the inlet valves of an engine the valves can be used to throttle the engine and there is no need for a separate e.g. butterfly throttle.

The motion of the roller follower 27 is mainly rotational during valve operation and therefore does not generate significant frictional losses.

Whilst the control arm 29 is shown extending from the shaft 21 which is rotated to control the position of the arm 29 and thus control the operating mode of the mechanism, it is possible mount the control arm 29 on the shaft 17 instead, which would then be rotated e.g. by an electric motor to control the operation of

the mechanism.

Whilst above the mechanism has a roller follower 18 which abuts the cam 13 and this is advantageous to keep frictional losses low, a follower pad could be used instead.

Whilst above the valve 10 is an inlet valve, the valve could equally well be an exhaust valve controlling flow of combined gases from the chamber 11. Indeed, the mechanism would be suitable to facilitate operation of an engine by controlled auto-ignition in part load conditions. The exhaust valve opening period could be varied to shut the exhaust valve early in an exhaust stroke to trap combusted gases. The trapped combusted gases would then be mixed with the next charge of fuel and air and the mixture compressed. The compressed mixture would ignite by auto-ignition. The amount of trapped combusted gases could be varied to vary the timing of the auto-ignition.

Whilst above one roller 27 is shown engaging one rocker 16 of one inlet valve 10, it is envisaged that a pair of rockers could be mounted on a single control arm 28 to engage, one each, a pair of rockers which drive a pair of inlet valves(or a pair of exhaust valves). It is thought that a single cam (e.g. 13 or 120) could be used to drive a pair of inlet valves (or pair of exhaust valves) via a mechanism comprising a pair of roller followers such as 27.

CLAIMS

1. A valve operating mechanism for operating a poppet valve comprising:

a cam mounted on a cam shaft for rotation therewith;

a first rocker which is pivotally mounted on a first rocker shaft and which is driven by the cam to pivot in an oscillatory manner about the first rocker shaft;

a second rocker which is pivotally mounted on a second rocker shaft spaced apart from the first rocker shaft and which engages the poppet valve so that pivoting of the second rocker causes motion of the poppet valve; wherein

the first rocker has a cam surface and the second rocker has a reaction surface and the cam surface and the reaction surface face each other;

a follower member is arranged between the cam surface and the reaction surface in simultaneous abutment with both surfaces;

as the first rocker pivots under camming action of the rotating cam the follower member moves relative to the cam surface and relays camming action of the part of the cam surface engaged by the follower member to the reaction surface and thereby to the second rocker to cause the second rocker to pivot about the second rocker shaft and hence impart motion to the poppet valve; and

the follower member is connected to a control mechanism which can move the follower member relative to the cam surface in order to vary which part of the cam surface is engaged by the

follower member during pivoting of the first rocker and thereby to vary the pivoting of the second rocker and hence the motion of the poppet valve;
characterised in that

the first and second rocker shafts are arranged with respect to one another and the control mechanism is configured such that when the follower member is moved by the control mechanism to increase maximum lift of the poppet valve then distance between the follower member and the first rocker shaft is increased and distance between the follower member and the second rocker shaft is decreased.

2. A valve operating mechanism as claimed in claim 1 wherein:

the cam surface on the first rocker has a portion of constant radius with respect to the first rocker shaft and when the follower member engages the constant radius portion of the cam surface of the first rocker then no lift is transmitted to the poppet valve; and

the control mechanism can constrain the follower member to move along the constant radius portion of the control surface for a part of the oscillation of the first rocker and the control mechanism can vary duration and lift of the poppet valve by increasing and decreasing a distance travelled by the follower member along the constant radius portion of the cam surface.

3. A valve operating mechanism as claimed in claim 2 wherein the control mechanism can deactivate the poppet valve by constraining the follower member to engage the constant radius portion of the cam surface of the first rocker throughout a complete oscillation of the first rocker.

4. A valve operating mechanism as claimed in any one of the preceding claims wherein in order to decrease maximum valve lift the control mechanism displaces the follower member to decrease distance between the follower member and the first rocker shaft and to increase distance between the follower member and the second roller shaft.

5. A valve operating mechanism as claimed in any one of the preceding claims wherein the follower member is a roller follower and the first and second rockers when pivoting always pivot in opposite senses to one another.

6. A valve operating mechanism as claimed in claim 5 wherein the control mechanism comprises:

a first control arm on which the roller follower is mounted to be freely rotatable; and

a second control arm to which the first control arm is pivotally connected such that the first control arm is freely rotatable about the pivotal connection; wherein

one of the first and second rocker shafts forms part of the control mechanism with the second control arm being mounted on the relevant rocker shaft to rotate therewith and the relevant shaft being rotatable to act via the first and second control arms to move the roller follower so as to vary the part of the cam surface engaged by the roller follower during pivoting of the first rocker.

7. A valve operating mechanism as claimed in any one of the preceding claims comprising a roller follower mounted on the first rocker which directly engages the cam.

8. A valve operating mechanism as claimed in any one

of claims 1 to 7 wherein the first rocker is connected to a first end of a push rod which has a second end which engages the cam.

9. An internal combustion engine having as inlet valves controlling gas flow into working cylinders a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of the preceding claims wherein the lifts and opening durations of the poppet valves are varied to vary throttling of the engine.

10. An internal combustion engine having as exhaust valves controlling gas flow from working cylinders a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of claims 1 to 8 wherein the lifts and opening durations of the poppet valves are varied with variations in engine speed and/or load.

11. An internal combustion engine as claimed in claim 10 wherein in part load conditions the exhaust valves are closed early in each exhaust stroke to trap combusted gases so as to generate in the working cylinders conditions suitable for auto-ignition.

12. A valve operating mechanism substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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Amendments to the claims have been filed as follows

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CLAIMS

1. A valve operating mechanism for operating a poppet valve comprising:

a cam mounted on a camshaft for rotation therewith;

a first rocker which is pivotally mounted on a first rocker shaft and which is driven by the cam to pivot in an oscillatory manner about the first rocker shaft; and

a second rocker which is pivotally mounted on a second rocker shaft spaced apart from the first rocker shaft and which engages the poppet valve so that pivoting of the second rocker causes motion of the poppet valve; wherein

the first rocker has a cam surface and the second rocker has a reaction surface and the cam surface and the reaction surface face each other;

a follower member is arranged between the cam surface and the reaction surface in simultaneous abutment with both surfaces;

as the first rocker pivots under camming action of the rotating cam the follower member moves relative to the cam surface and relays camming action of the part of the cam surface engaged by the follower member to the reaction surface and thereby to the second rocker to cause the second rocker to pivot about the second rocker shaft and hence impart motion to the poppet valve; and

the follower member is connected to a control mechanism which can move the follower member relative to the cam surface in order to vary which part of the cam surface is engaged by the

follower member during pivoting of the first rocker and thereby to vary the pivoting of the second rocker and hence the motion of the poppet valve; characterised in that

the first and second rocker shafts are arranged with respect to one another and the control mechanism is configured such that when the follower member is moved by the control mechanism to increase maximum lift of the poppet valve then distance between the follower member and the first rocker shaft is increased and distance between the follower member and the second rocker shaft is decreased.

2. A valve operating mechanism as claimed in claim 1 wherein:

the cam surface on the first rocker has a portion of constant radius with respect to the first rocker shaft and when the follower member engages the constant radius portion of the cam surface of the first rocker then no lift is transmitted to the poppet valve; and

the control mechanism can constrain the follower member to move along the constant radius portion of the control surface for a part of the oscillation of the first rocker and the control mechanism can vary duration and lift of the poppet valve by increasing and decreasing a distance travelled by the follower member along the constant radius portion of the cam surface.

3. A valve operating mechanism as claimed in claim 2 wherein the control mechanism can deactivate the poppet valve by constraining the follower member to engage the constant radius portion of the cam surface of the first rocker throughout a complete oscillation of the first rocker.

4. A valve operating mechanism as claimed in any one of the preceding claims wherein in order to decrease maximum valve lift the control mechanism displaces the follower member to decrease distance between the follower member and the first rocker shaft and to increase distance between the follower member and the second roller shaft.

5. A valve operating mechanism as claimed in any one of the preceding claims wherein the follower member is a roller follower and the first and second rockers when pivoting always pivot in opposite senses to one another.

6. A valve operating mechanism as claimed in claim 5 wherein the control mechanism comprises:

a first control arm on which the roller follower is mounted to be freely rotatable; and

a second control arm to which the first control arm is pivotally connected such that the first control arm is freely rotatable about the pivotal connection; wherein

one of the first and second rocker shafts forms part of the control mechanism with the second control arm being mounted on the relevant rocker shaft to rotate therewith and the relevant shaft being rotatable to act via the first and second control arms to move the roller follower so as to vary the part of the cam surface engaged by the roller follower during pivoting of the first rocker.

7. A valve operating mechanism as claimed in any one of the preceding claims comprising a roller follower mounted on the first rocker which directly engages the cam.

8. A valve operating mechanism as claimed in any one

of claims 1 to 7 wherein the first rocker is connected to a first end of a push rod which has a second end which engages the cam.

9. An internal combustion engine having as inlet valves controlling gas flow into working cylinders a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of the preceding claims wherein the lifts and opening durations of the poppet valves are varied to vary throttling of the engine.

10. An internal combustion engine having as exhaust valves controlling gas flow from working cylinders a plurality of poppet valves each operated by the valve operating mechanism claimed in any one of claims 1 to 8 wherein the lifts and opening durations of the poppet valves are varied with variations in engine speed and/or load.

11. An internal combustion engine as claimed in claim 10 wherein in part load conditions the exhaust valves are closed early in each exhaust stroke to trap combusted gases so as to generate in the working cylinders conditions suitable for auto-ignition.

12. A valve operating mechanism substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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Application No: GB 0206179.4 **Examiner:** Catherine Allen
Claims searched: 1 to 12 **Date of search:** 10 September 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): F1B: BB130, F2K: K3B1A2; K3B1A3

Int Cl (Ed.7): F01L: 1/18; 13/00

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB2200952	STIDWORTHY	
A	EP1072762	PEUGEOT CITROEN AUTOMOBILES SA	
A	WO95/09298	LOTUS CARS LTD	
A	US5365895	MOTIVE HOLDINGS LTD	
A	US4495902	INVESTMENT RARITIES INC	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.